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(54) **Array antenna.**

(57) The invention relates to an array antenna (1) comprising a number of antenna elements (3.1-3.8, 4.1-4.8). The antenna elements are divided up into a first group of at least two antenna elements (3.1, 3.3, 3.5, 3.7, 4.1, 4.3, 4.5, 4.7), having a first main lobe direction, and a second group of at least two antenna elements (3.2, 3.4, 3.6, 3.8, 4.2, 4.4, 4.6, 4.8), having a second main lobe direction. In order to produce a number of fixed antenna patterns of an attractive type, between which the array antenna can be switched, the array antenna is provided, according to the invention, with a switchable phase network (37) and a specific feed network (21, 22). The feed network is divided up, between the feedpoint (20) and the antenna elements, into a first branching network (21) for feeding the said first group of antenna elements, and a second branching network (22) for feeding the said second group of antenna elements. The first branching network is arranged to initiate essentially the same phase shift between the feedpoint and the respective antenna elements within the first group. The second branching network is arranged to initiate essentially the same phase shift between the feedpoint and the respective antenna elements within the second group. The array antenna is suitable, for example, as a base station antenna in a mobile telephone system.

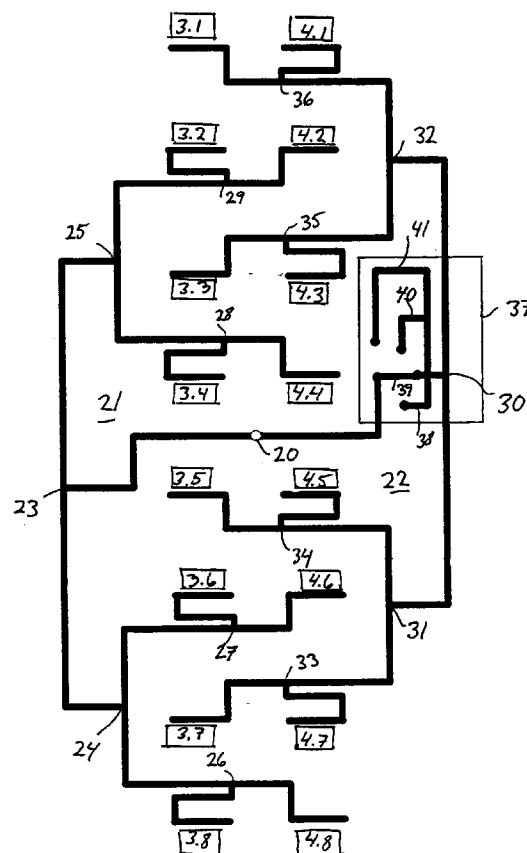


Fig 4

The present invention relates to an array antenna comprising a number of antenna elements divided up into a first group of at least two antenna elements, having a first main lobe direction, and a second group of at least two antenna elements, having a second main lobe direction distinct from the first main lobe direction, feed networks for feeding the antenna elements, and means for mutual shifting of the phase position between the first group of antenna elements and the second group of antenna elements.

An array antenna according to the above is already known from SE C 8301736-8. Associated with each pair formed by an antenna element from each group of antenna elements are two hybrid circuits and two phase shifters. By means of controlling the incorporated phase shifters, it is possible to produce a scanning lobe which sweeps across a large angle range. The antenna provides a possibility of high drive level in a sideways direction. Since each pair of antenna elements requires two hybrid circuits and two phase shifters, the antenna is relatively complex in terms of components and is therefore expensive. The antenna is suitable for advanced applications which require a scanning lobe and in which the cost of the antenna is not an important determining factor.

The object of the present invention is to produce an array antenna affording the possibility of high drive level, which is simple and robust in its construction, suitable for mass production and available at a reasonable price.

The object of the invention is achieved by means of an array antenna which is characterized by the fact that the means for mutual phase shifting comprise a phase network which can be switched between discrete positions, and by the fact that the feed network between feedpoint and antenna elements is divided up into a first branching network for feeding the said first group of antenna elements, and a second branching network for feeding the said second group of antenna elements, which first branching network is arranged to initiate essentially the same phase shift between the feedpoint and the respective antenna elements within the first group, and which second branching network is arranged to initiate essentially the same phase shift between the feedpoint and the respective antenna elements within the second group. The switchable phase network, in combination with the angle capacity of the antenna elements, means that the array antenna can be adjusted between a number of fixed lobe shapes. The array antenna permits a flexible drive of the antenna lobes in desired directions in the horizontal plane.

According to a preferred embodiment, the switchable phase network comprises a number of alternative antenna signal routes of different phase shift between input and output. The antenna signal routes can be coupled-in one by one as chosen.

According to a further preferred embodiment, an-

tenna elements having the second main lobe direction are turned by an angle greater than 0° and not more than 90° , and preferably of the order of magnitude of 60° , in relation to antenna elements having the first main lobe direction. A turn of the order of magnitude of 60° , involving the antenna openings of two adjacent antenna elements turned towards one another forming an angle of the order of magnitude of 120° , means that individual elements can easily be phased jointly to cooperate in order to form a number of different coverage diagrams, and at the same time the antenna has a manageable size.

A specific embodiment which, with antennas of manageable size, provides attractive coverage diagrams is characterized by the fact that the antenna is made up of two identical rows of four antenna elements belonging to the first group and four antenna elements belonging to the second group included in each row. By arranging a number of horizontal rows or arrays of antenna elements in the vertical direction, it is possible to influence the shape of the lobes in the vertical plane.

Phase shifts of 0° , 90° or 180° are examples of phase shifts between the first group and second group of antenna elements which result in favourable coverage diagrams, and according to one embodiment the phase network of the array antenna is arranged to couple-in the said phase shifts.

Patch elements which are known per se and which are available for purchase in a number of alternative designs are examples of antenna elements which are suitable for use in the array antenna. Such patch elements can be set up in a folded structure, in which the folding of the structure determines the main lobe directions of the patch elements. The folded structure with the patch elements is expediently surrounded by a casing. The casing can have both a protective function and a design function. In addition, the casing can facilitate the assembly of the array antenna.

The array antenna is suitable, for example, for use as a base station antenna in a mobile telephone system. The fixed lobe shapes can in this case be dimensioned so as to cover a number of normal road traffic situations, for example traffic essentially at right angles to the array antenna, traffic essentially parallel to the array antenna, or traffic situations at cross-roads. The array antenna has a shape and size which are such that it can merge easily into the urban environment. Frequencies used at present for radio-telephony are around 900 MHz and 1800 MHz. The array antenna is suitable in terms of its dimensions for operating at these frequencies, and an advantageous embodiment is characterized by the fact that the antenna is dimensioned for frequencies within the radio-telephony range, preferably around 900 MHz or 1800 MHz.

The invention will be described in greater detail

hereinbelow on the basis of an exemplary embodiment and with reference to the attached drawings, in which Figure 1 shows an array antenna according to the invention without a surrounding casing, Figure 2 shows the array antenna according to Figure 1 enclosed in a casing, Figure 3 shows, in an exploded view, examples of the construction of a patch element, Figure 4 shows examples of a feed network for feeding the patch elements in an array antenna according to the invention, and Figures 5a-5d show four examples of antenna patterns obtained by means of computer programs simulating the function of an array antenna according to the invention for four imaginary fixed lobe shapes.

The array antenna 1 shown in Figure 1 comprises a folded structure 2, preferably of sheet metal material, in which 16 patch elements 3.1-3.8, 4.1-4.8 are arranged. The patch elements will be described in greater detail later with reference to Figure 3. The patch elements are divided into two rows in which the patch elements 3.1-3.8 form a first row or array, and the patch elements 4.1-4.8 form a second row. The antenna structure is angled in such a way that all patch elements having an odd last digit in the reference number have a first main lobe direction, and patch elements having an even last digit in the reference number have a second main lobe direction. The main lobe directions of the patch elements normally coincide with the perpendicular line in relation to the surface of each patch element. The patch elements having a first main lobe direction are oriented in relation to patch elements having the second main lobe direction in such a way that two patch elements angled towards one another form an angle α of between 90° and 180° , and preferably an angle of the order of magnitude of 120° .

Figure 2 shows the array antenna according to Figure 1 enclosed in a casing 5 with formations 6,7 provided with holes for facilitating the assembly of the array antenna. The antenna can be secured discreetly by simple means on, for example, a house wall in an urban environment.

The array antenna incorporates patch elements which are known per se, and such a patch element is therefore described only in outline hereinbelow. As can be seen from Figure 3, an antenna element in the form of a patch element can be built up from a number of essentially plane sheets of metal and dielectric. At the very bottom, according to the figure, there is a first metal sheet 8 functioning as an earthing plate. The first metal sheet 8 is covered by a first sheet of dielectric 9. The upper side of the first dielectric is covered with a metal strip 10 for electrical connection between the central part of the patch element and an outer edge 11. A second dielectric sheet 12 is arranged on top of the first dielectric sheet 9. A second metal sheet 13 is arranged on top of the second dielectric sheet 12. The second metal sheet 13 has an

opening 14 in the centre and covers a middle area of the second dielectric sheet situated between the said opening and the peripheral parts 15 of the second dielectric sheet. A third dielectric sheet 16 is arranged on top of the second metal sheet 13 and the second dielectric sheet 12. A surface area essentially corresponding to the outer limit of the second metal sheet is covered by a third metal sheet 17.

The patch element is fed via a coaxial cable (not shown) whose jacket is connected to the metal sheet 8 functioning as an earthing plate and whose inner conductor is connected to the metal strip 10. The radiation pattern for the patch element shows a main lobe direction essentially at right angles to the sheets incorporated in the patch elements.

Figure 4 shows feed and phase networks which are incorporated in the array antenna 1 described with reference to Figure 1. The feed and phase networks can be arranged on the rear face of the structure 2 and cannot therefore be seen in Figure 1. At the centre of the feed network there is a feedpoint 20. A first branching network 21 and a second branching network 22 start from the feedpoint. Both branching networks comprise branches in three stages. In the first branching network 21 there is a first branch at point 23, second branches at points 24 and 25, and third branches at points 26-29. In the second branching network there is a first branch at point 30, second branches at points 31,32, and third branches at points 33-36. When the branching networks 21 and 22 have been branched in three stages, a connection of the patch elements to the branching networks is made. In Figure 4 the reference numbers for the respective patch elements have been indicated in the areas where connection to the branching networks takes place.

A switchable phase network 37 is coupled-in between the feedpoint 20 and the first branch point 30 of the second branching network. The phase network 37 comprises four parallel antenna signal routes 38-41. The phase network 37 is shown in the position in which signal route 39 is coupled-in and is intended to produce essentially the same phase shift between the feedpoint 20 and the patch elements 3.1-3.8, 4.1-4.8 in the two branching networks 21 and 22. Coupling-in of the signal route 38 results in a slight phase shift between signals which reach patch elements with an odd last digit in the reference number and signals which reach patch elements with an even last digit in the reference number. Coupling-in of signal route 40 increases the phase shift further, and coupling-in of signal route 41 results in a phase shift of 180° , i.e. the output signals from the two branching networks lie in anti-phase. By setting the change-over switch of the phase network to an intermediate position, the feeding of the patch elements connected to the second branching network 22 can be coupled-out completely. The coverage required for a specific

case can be easily set by means of a simple manoeuvre by an operator, for example by acting on an adjustable knob (not shown). The change-over switch is in this case allocated suitably marked positions for the most common traffic situations, for example traffic in the longitudinal direction of the road, at road crossings or round street corners.

Figures 5a-5d show examples of four antenna patterns obtained by simulating the function of the array antenna. The antenna patterns show the vertically polarized E-field which is obtained for antenna patterns in the horizontal plane.

Figure 5a shows the case in which all patch elements are operating in the same phase. As can be seen from the antenna pattern, a strong lobe 42 is obtained at right angles to the antenna. This feeding of the patch elements in the same phase is suitable for covering a stretch of road in front of the antenna which is at right angles to the antenna.

Figure 5b shows the case in which the patch elements having the first main lobe direction are fed in phase, and the patch elements having the second main lobe direction are fed in phase, but shifted 180° in relation to the patch elements having the first main lobe direction. Two powerful lobes 43,44 with high drive level are obtained. This feeding is suitable when coverage is required along a road alongside which the antenna is positioned. The two lobes 43,44 cover the road in opposite directions starting from the antenna.

Figures 5c and 5d show feeding examples suitable for crossings or street corners. According to Figure 5c a group of patch elements having a common main lobe direction are fed in phase, while patch elements of another main lobe direction are coupled-out. Two strong lobes 45 and 46 separated by almost 90° are obtained in this case, which permits good coverage at normal street corners. According to Figure 5d a first group of patch elements having a common main lobe direction are fed in phase, and a second group of patch elements having another common main lobe direction are fed in phase, but are phase-shifted 90° in relation to the first group. Three strong lobes 47,48,49 are obtained.

The invention is not in any way restricted to the exemplary embodiment described hereinabove, but instead a number of alternative embodiments are possible within the scope of the invention. For example, the number of antenna elements per row can be varied within wide limits. The number of rows with antenna elements can likewise vary.

Claims

1. Array antenna comprising a number of antenna elements divided up into a first group of at least two antenna elements, having a first main lobe direction, and a second group of at least two an-

tenna elements, having a second main lobe direction distinct from the first main lobe direction, feed networks for feeding the antenna elements, and means for mutual shifting of the phase position between the first group of antenna elements and the second group of antenna elements, characterized in that the means for mutual phase shifting comprise a phase network which can be switched between discreet positions, and in that the feed network between feedpoint and antenna elements is divided up into a first branching network for feeding the said first group of antenna elements, and a second branching network for feeding the said second group of antenna elements, which first branching network is arranged to initiate essentially the same phase shift between the feedpoint and the respective antenna elements within the first group, and which second branching network is arranged to initiate essentially the same phase shift between the feedpoint and the respective antenna elements within the second group.

2. Array antenna according to the preceding patent claim, characterized in that the switchable phase network between input and output comprises a number of alternative antenna signal routes of different phase shift, which can be coupled-in one by one as chosen.
3. Array antenna according to either of the preceding patent claims, characterized in that antenna elements having the second main lobe direction are turned by an angle greater than 0° and not more than 90°, and preferably of the order of magnitude of 60°, in relation to antenna elements having the first main lobe direction.
4. Array antenna according to any of the preceding patent claims, characterized in that the antenna is made up of two identical rows with four antenna elements belonging to the first group and four antenna elements belonging to the second group included in each row.
5. Array antenna according to any of the preceding patent claims, characterized in that the phase network is arranged to couple-in a phase shift of 0°, 90° or 180° between the first group and the second group of antenna elements.
6. Array antenna according to any of the preceding patent claims, characterized in that the phase network is arranged to couple-out one of the said groups of antenna elements.
7. Array antenna according to any of the preceding patent claims, characterized in that the antenna

elements consist of patch elements built up from essentially plane sheets of metal and dielectric.

8. Array antenna according to Patent Claim 7, characterized in that the patch elements are arranged in a folded structure surrounded by a casing. 5
9. Array antenna according to any of the preceding patent claims, characterized in that the antenna is dimensioned for frequencies within the radio-telephony range, preferably around 900 MHz or 1800 MHz. 10

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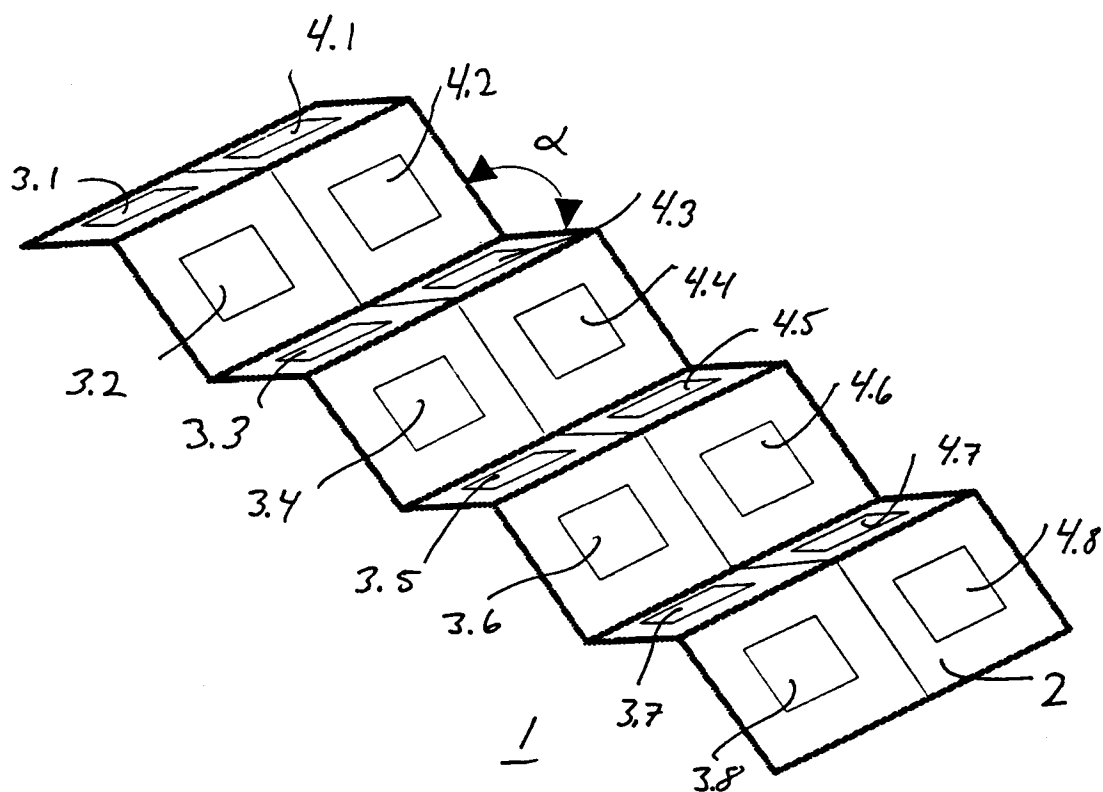


Fig 1

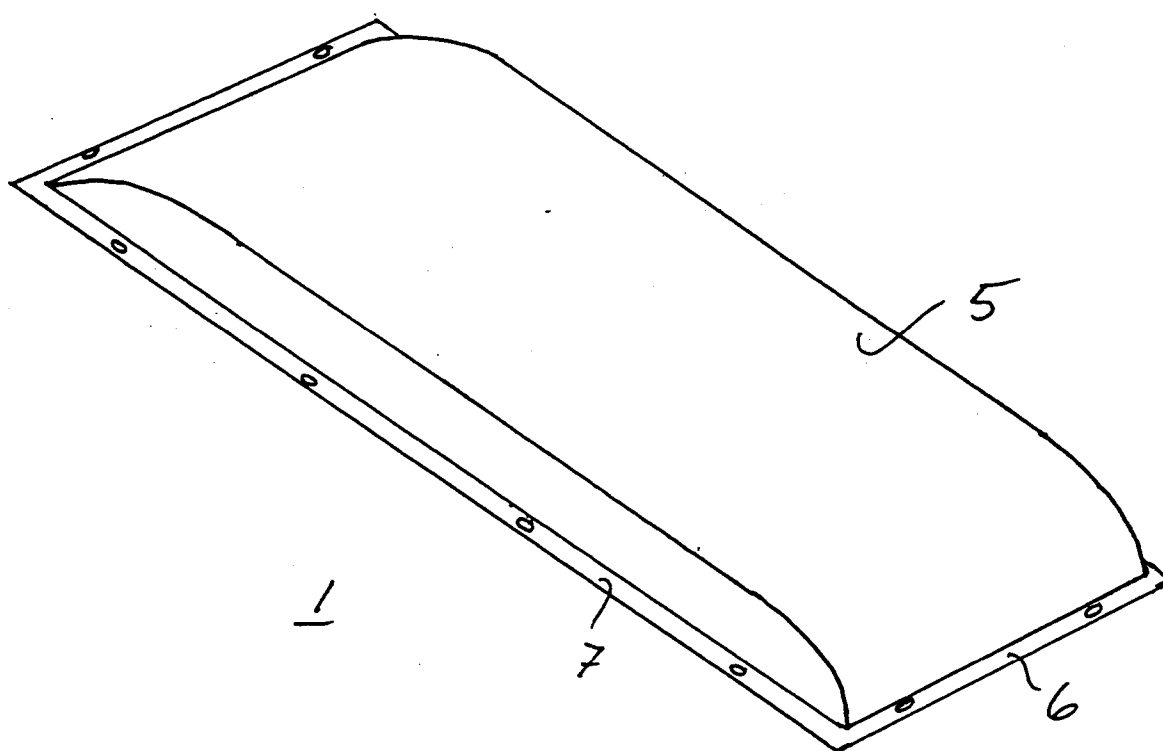


Fig 2

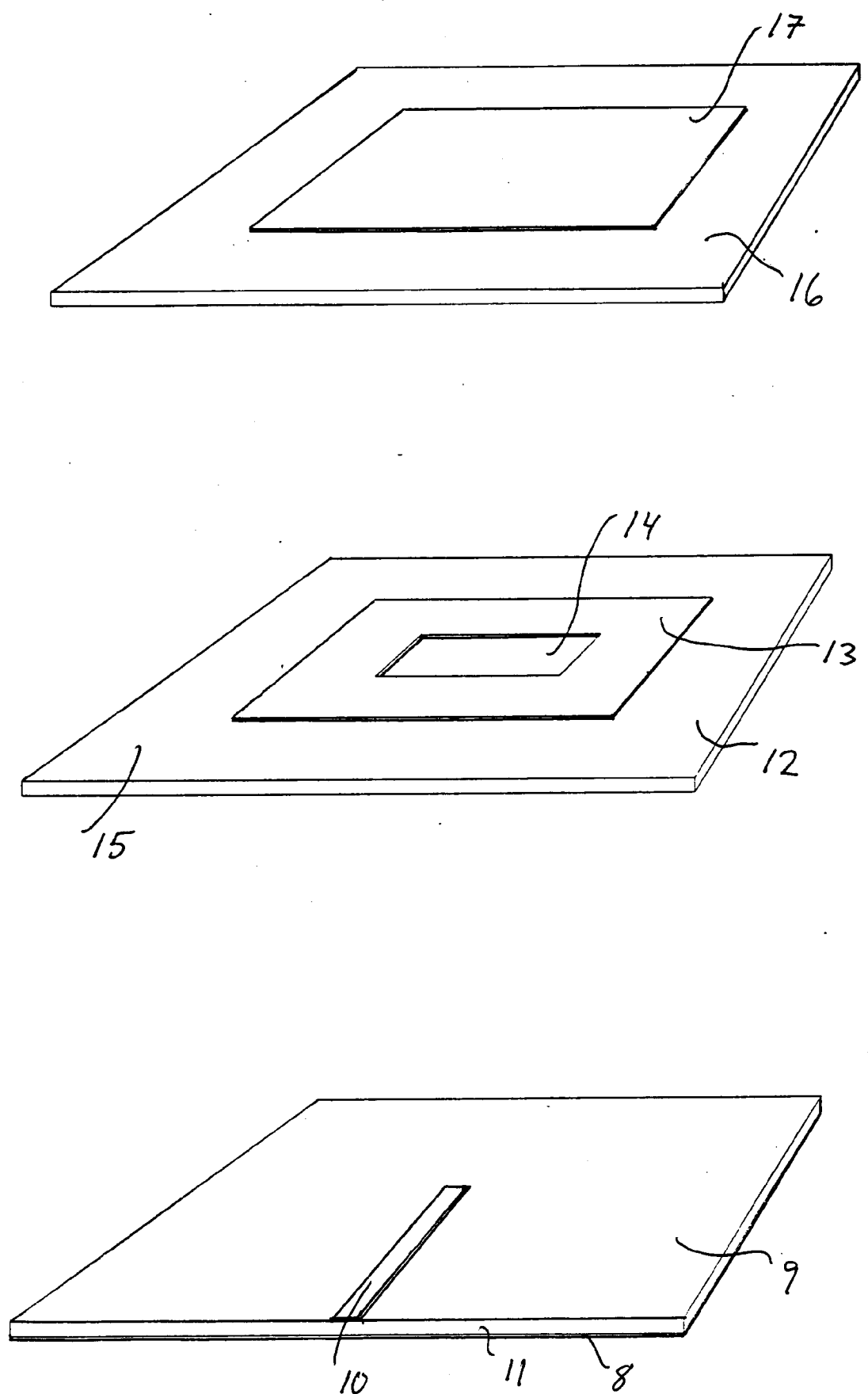


Fig 3

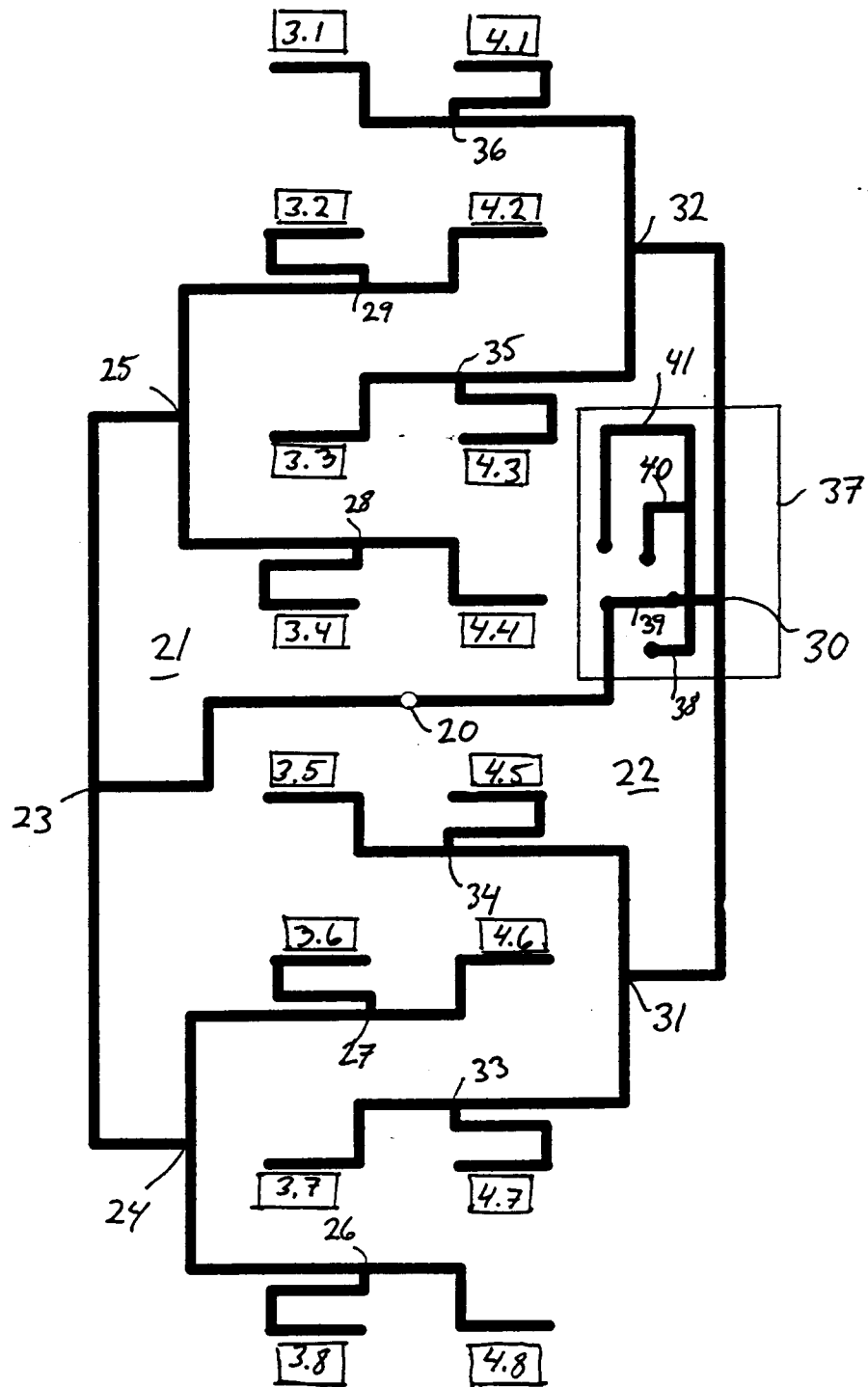


Fig 4

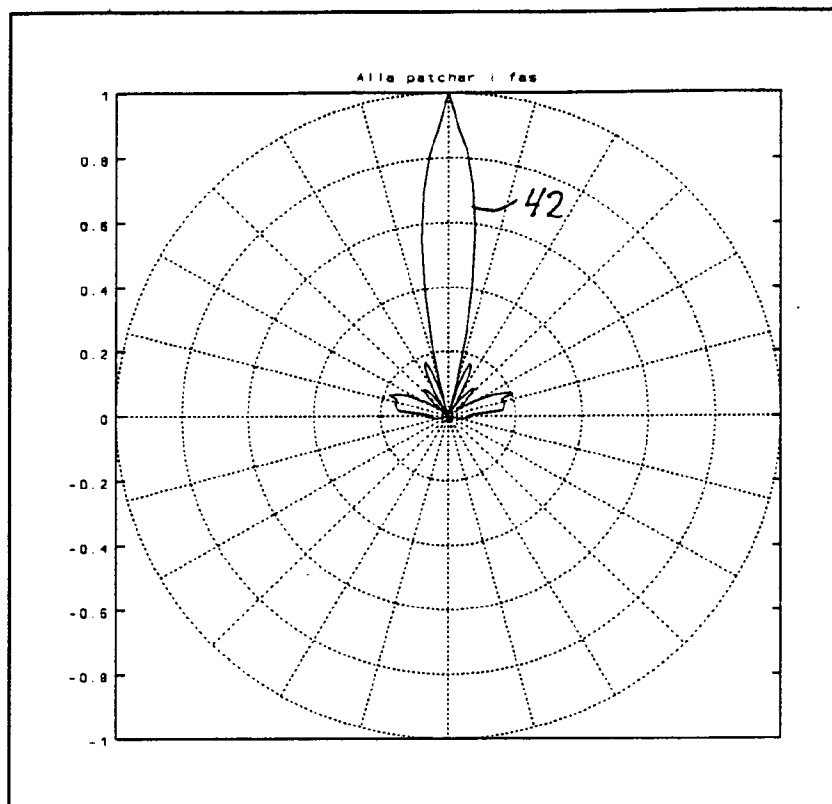


Fig 5a

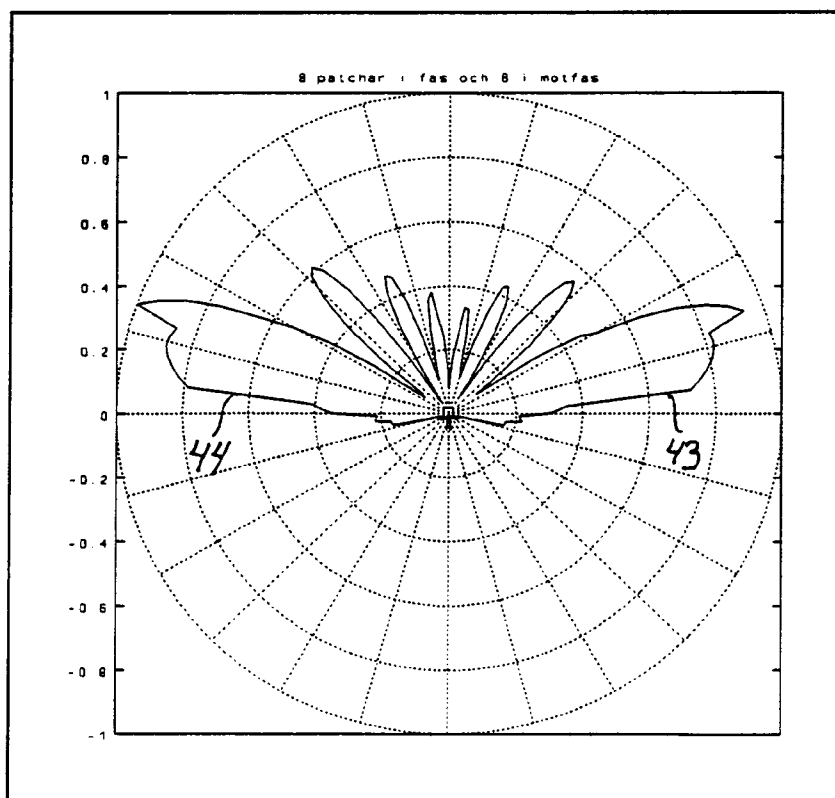


Fig 5b

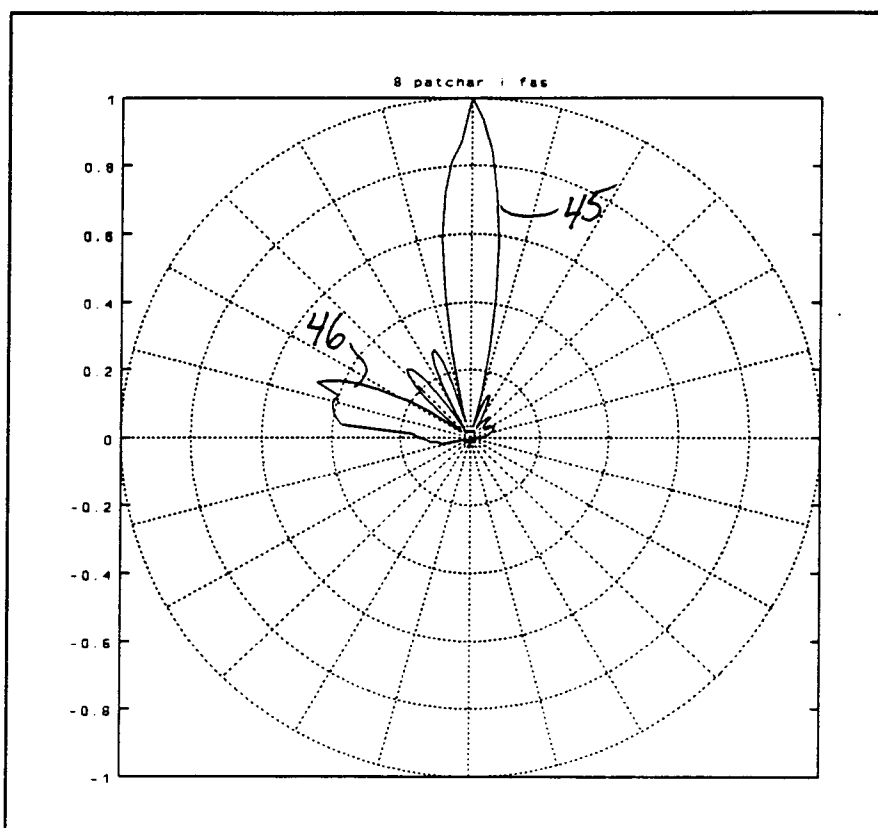


Fig 5c

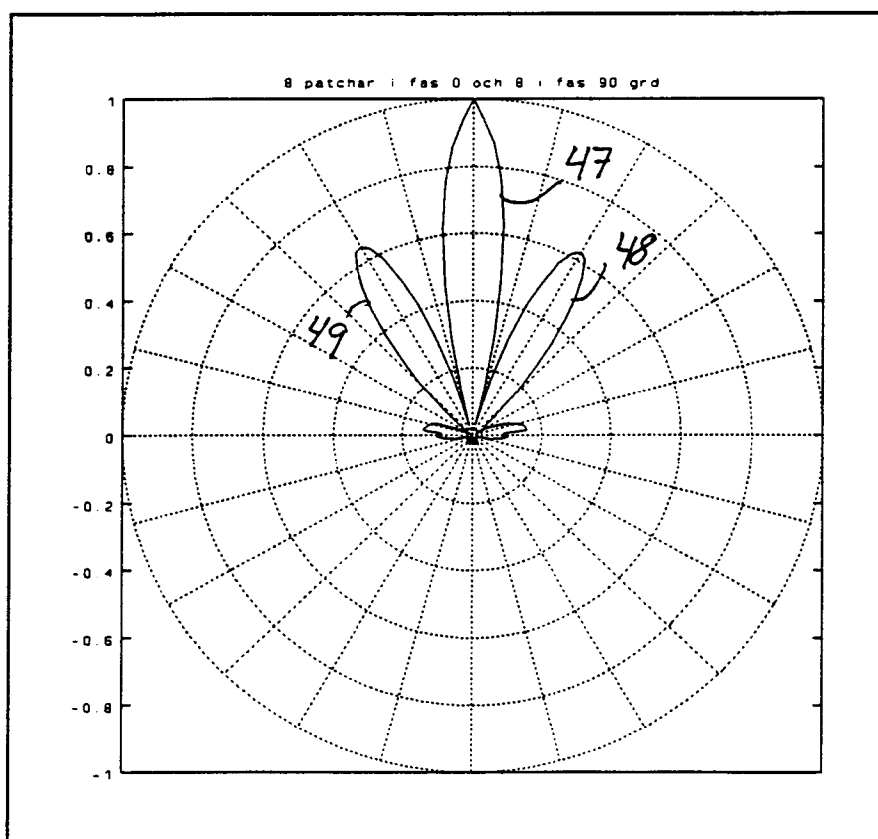


Fig 5d



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 94 85 0021

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	US-A-4 833 482 (TRANG N. TRINH ET AL.) ---	1,2,4-7	H01Q3/30
A	SE-B-455 907 (PHILIPS NORDEN AB) ---	1-6	
A	EP-A-0 456 579 (THOMSON-CSF) ---	1	
A	EP-A-0 415 818 (THOMSON-CSF) * figure 1 *	1,2,5	
A	PATENT ABSTRACTS OF JAPAN vol. 11, no. 11 (E-470) & JP-A-61 186 001 (FUJITSU LTD.) 19 August 1986 * abstract * -----	1,5	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			H01Q
Place of search STOCKHOLM		Date of completion of the search 5 May 1994	Examiner MAGNUSSON GÖRAN
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